How Does GPS Know Where I Am?

By *Sarah O'Sullivan*, GIS Mapping Forester, Alabama Forestry Commission

You may have heard it on commercials or seen it in a car . . . or you may even have a device yourself, but still you wonder. What exactly is GPS? How does it know exactly where I am? Well, stay tuned because these questions and more will be answered in this article.

GPS (Global Positioning Systems) was originally formulated by the Department of Defense. Even though this service costs the government millions of dollars each year to continue, it is free of charge to the public. The GPS unit in your car or in your hand receives signals from a network of satellites that are constantly orbiting the earth. By receiving these signals, the GPS unit uses a process called triangulation to find its current location. The unit will measure the difference in time between when the satellite signal was sent and when it was received by the GPS receiver. This, along with knowing the speed the signal is sent, results in the calculation of distance from that satellite. Each satellite will calculate the GPS receiver in a certain range. Where the ranges overlap is the location of the GPS receiver. The more satellites used by the GPS receiver, the smaller the overlapping area. Basically the GPS receiver measures the change in time between when the signal was sent and when it was received. If the clock inside the GPS receiver is slightly off, then error can occur.

The satellite signal carries three very important pieces of information that are needed by the GPS receiver. This information includes the satellite ID (pseudo-random code), the location of the satellite (ephemeris data), and the condition of the satellite (almanac data) such as operational or dysfunctional. If the satellite is inaccurate about its location, an orbital (also known as ephemeris) error could occur.

The satellite's signal travels by line-of-sight. If the sky can be seen *through* something, then a signal can be received. If the sky cannot be seen, then problems may arise in receiving a signal. In other words, satellite signals can move through clouds and glass (among other things), but is obstructed by solid objects such as buildings, mountains, and walls. Since the signal cannot go through the solid objects, it bounces off the surface, resulting in a signal error called multipath. Also, if you are located indoors or in a dense forest, the ceiling may be so thick that it limits or even blocks your satellite reception. This could lead to position errors, or no signal.

So far in this article there have been several mentions of occasions for error, but the good news is that GPS receivers have built-in correctional systems to counteract those errors. WAAS (Wide Area Augmentation System) improves the accuracy of the GPS receiver to where there is only a 3-meter margin of error. The way that WAAS works is that it is made up of reference stations that are spread throughout the nation to form a network. The stations receive the satellites signals and determine if there are any errors. This information is then passed on to the master station which gathers all of the corrections for that area. The corrections are then sent to another type of satellite called a geostationary communications (GEO) satellite. It is from the GEO satellite that your GPS receiver receives the correction. Just as with the GPS receiver, the WAAS signals travel by line-of-sight, meaning that if a solid object obstructs the path, the signal will not go through. Things such as mountains, canyons, or even a dense forest could block a WAAS signal.

One factor to consider when purchasing a GPS unit is its purpose. If it will be used for navigation in a car, then you would want one that can be mounted to leave your hands free for driving. If you plan to use the GPS unit to take points on your property, then possibly a rugged waterproof handheld unit would be more applicable. It is important to find a unit that will meet both the user's need and budget.